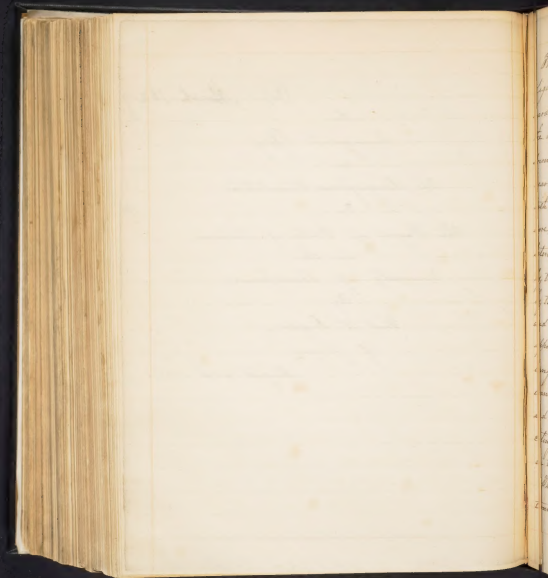


Paper March 1829

An
 Inaugural Essay
 on
 The Sanguiferous Circulation,
 For
 The Degree of Doctor of Medicine,
 In the
 University of Pennsylvania,
 By
 Thos W. Ingram,
 of Georgia.
 August 28th 1828



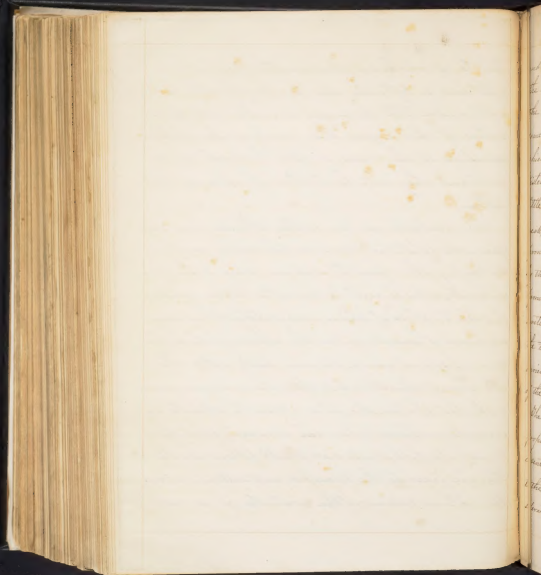
The Heart is a muscular viscus of a conoidal figure, having a base which looks obliquely upwards and backwards, towards the right side of the vertebrae, and an apex pointing somewhat downwards and to the left, presenting its point near the junction of the fifth and sixth ribs with their cartilages. It is incarcerated, as it were, within the thoracic cavity, having the ribs laterally, the ribs and vertebral column posteriorly, the sternum and costal cartilages anteriorly, the converging of these parietes superiorly, and the diaphragm inferiorly. More closely approximated to it, on each side, is located the lungs; it is more closely concealed by a membranous sack, that surrounds it, and secretes and contains a vapour for the purpose of lubricating it, termed the pericardium; and seated in the duplicature of the mediastinum.

The heart consists, according to some Anatomical and Physiologists writers of four cav-



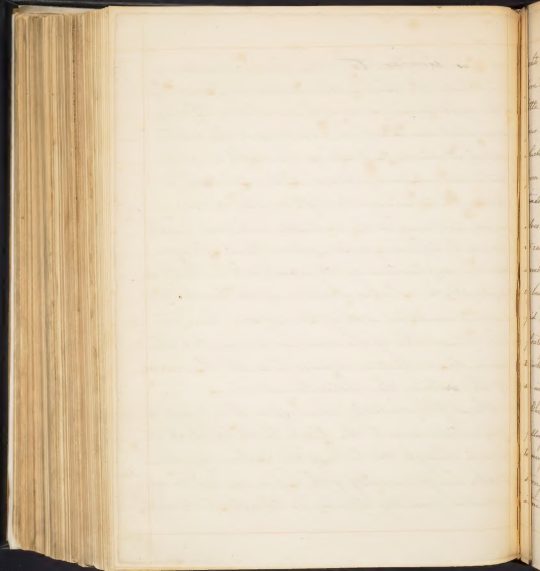
ities, to of which are denominated Ventricles, a right and a left; the other two, Auricles, also, a right and a left: those only I shall treat of as cavities of this organ; these, merely as funnel-like expansions of the veins, as they terminate in the heart, and they will be treated of, when on that system.

The Ventricles are two cavities differing from each other somewhat in form, in dimension, in the thickness of their parietes, and in some other particularities, which will be hereafter taken notice of, when treating of them separately. They are composed of muscular fibres, the exterior of which observe a spiral course, the more deeply seated interlock among themselves, and the interior, very irregular in this last stratum, the fibres appear to separate in fasciculi or columns (*columnae carnae*), from those to four of which, are formed small fibrous chords, that are fixed to the tricuspid and mitral valves. The exterior covering of the ventricles is serous,



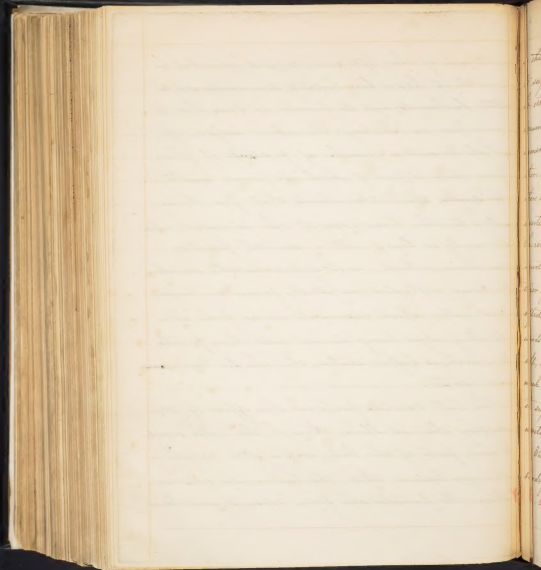
and is similar. To the lining membrane of the chest, the pleura. The interior, is formed by the reflection of a smooth membrane, differing somewhat in its nature, according to the cavity which it lines: that, lining the right, is easily distended, not easily torn, and it will spiff a little; that, lining the left, on the contrary, is weak, not easy to be distended, and very much prone to become spiffed, especially in old age. By the duplicature of this membrane on itself, is formed the valvular structure of the heart. Both cavities consisting each of two orifices: those at the termination of the veins, are denominated the auriculo-ventricular orifices; those at the origin of the arteries, the ventriculo-arterial.

The Right Ventricle, whose office it is, to give a propulsive force to the black blood, by which it is sent, through the tube of the pulmonary artery, to the lungs, is a cavity of the organ now under consideration, presenting the form of a triangle, situated on the



right side of the left ventricle, and somewhat before it: it has a base looking downwards, and a little backwards; and its parietes are from three to four lines in thickness; the interior surface of which presents a number of fasciculi of fibres, from three to four of which are formed small, tendinous, threadlike chords, that fix themselves to the loose edges of the tricuspid valve. Its cavity is lined with a smooth peculiar membrane, which, as it approaches the auricle, by being reflected on itself, forms the tricuspid valve, which receives its name from its floating edges being divided into three points, to which, as before stated, the chordae tendinae are inserted.

The Left Ventricle performs the office of propelling the red blood, through the aortic canal, to every part of the body, and is of a much stronger texture, than the last under consideration. Its parietes are from seven to nine lines



is thickest, being thicker at its exterior, than at
its interior is another valve. As the interior of
the other contracts, so does this, and it drives
a number of muscular fasciculi, which are more
numerous, thicker and stronger than those in the
other, some in front, others, more are to the other;
then terminating in the anterior tendons, to be
inserted in the lower edges of the internal valve.
The body of the contractile part is the same as
a smooth membrane, similar to that of the con-
tractile part last described, which, after being
reflected over its cavity, and as it advances to
wards the column verrucosum, is doubled upon it-
self, so as to form an internal valve, which is
much thicker and stronger than the first.
Its superior edge being divided into two equal
parts, whence its name.

The heart, like the parts of the body, has
blood-vessels, nerves, and lymphatics.

The Arteries, arising out of the ventricles of



The ventricles of the heart, which are distinguished for the emergence of the blood from the common centre of the circulation, to each capillary system, are canals, nearly cylindrical, having a solid texture, and possessing in small degree of elasticity. They, at first, forming only two large tubes, the pulmonary and aortic, are soon after divided into branches, which again being subdivided, finally terminate in small ramifications, that very intimately anastomose among themselves, so as to form one entire network of vessels throughout the whole system.

The arteries are covered with a thin coat, varying a little in their appearance and properties, but also in their situation, structure and texture. Some of the fibres of which they are composed. Their coats are the tunicas, to wit an intima, an interior, and an inter. media.

The tunicas that being of a cellular texture, is condensed and compressed into a cylindrical



canal, as to form a kind of sheath or lining
for the protection of the other coats, is com-
posed of innumerable fibres running in its
direct course, closely interwoven among them-
selves. It forms an attachment to the adja-

cent texture externally, and also a movea-
ble adhesion to the middle coat. This lamina
is of a much greater strength than either of
the others; it is much thicker, it is by sur-
geons, on account of its resisting the ligature,
and remaining entire in surgical operations,
while the middle and interior coats are
divided.

The Exterior Coat, having the inner face
of these vessels, is a smooth membrane, nec-
essarily polished and inviolent with a humidity
for the easy conveyance of the blood; it is
thicker and stronger in that vessel carrying the
red blood than that which carries the black.
It is no other than the membrane lining the

10000

where the fibres are in a continuous
the same, which is not the case from these
cartilages when the union in the surface is so
deep so as to form the substance is separated
valves.

The Muller is fibrous coat, which gradually
diminishes in thickness as it recedes from the
heart, and these valves are so arranged, as to
form segments of circles, of a pale yellow
colour, and as the primary is to retain its in-
herent external shape, though embedded in its
contents. This coat has attracted the attention
of many Anatomists, and has been very differ-
ently described by them. Some class it under
the muscularia tend. others consider it
as homogeneous, whilst others again believe it
to be composed of an external elastic lamina,
and an interior muscular one. The first was the
opinion of McShanley, and was generally presu-
med to be the nearest approximation to truth.



This is the coat that gives elasticity to the arterial system.

The arteries are said to be composed of three cellular membranes, of which oxygen moves the.

The Pulmonary Artery, defined as the direct conveyance of the black blood from the right ventricle to the lungs, is a vessel of about twelve lines in its caliber, whose it springs out of the heart; at which place, is the origin of its external coat or tunic, the tunica albuginea or serosa, that are fixed in number with their convex edges adhering to the artery, and their concave ones loose, turning inwards, and running in the middle of the interstices of each, a small cartilaginous substance, called bony cartilage, which gives support to the valves, when they are forced against each other, to prevent the regurgitation of the blood into the ventricle, when it detaches itself. Between each valve and the parietes of the artery, a small cavity is formed, as from a dilatation of the coat,



named the sinus of Valsalva.

This artery proceeds directly after its origin, in a direction, upwards and somewhat backwards, till it gets to the junction & level of the aorta, at its curvature, where it bifurcates, sending a trunk to each lung. On account of the left lung being further from this separation of the artery the trunk that goes to it is longer and curved than that going to the right. These trunks, after they have penetrated the parenchymatous substance of these viscera, again divide, sending branches to the several lobules, which finally subdivide into minute ramifications that pervade every part of their structure, and terminate in the capillary system.

The porta, a canal through which the red blood flows, from the left auricle to all parts of the body, is at its origin anterior to, and concealed in view by, the pulmonary artery. As it emerges from the left auricle of



be seen, its interior walls being loaded on
with the semilunar valves are joined, which
are so similar to those of the pulmonary,
that it would be a loss of time to describe
them separately here, more than to say, they
are a little thicker and stronger, and there even
inscribed ~~inscribed~~ ^{inscribed} somewhat larger, each sinus,
that it resembles the same as those last
described.

The artery after advancing toward a small
distance, gives off the arteria innominata, two or
three lines further the left carotid; and about
the same distance moves up to the left
innominata, at which point it splits the blood and
is then saturated with blood; then it commences
a curve, with the convex surface above and the
concave below, which it completes by reaching
across and uniting to the fourth thoracic ver-
tebra, and then getting over the right bron-
chus artery, it terminates itself to the in-



libral column, somewhat to the left side, where it descends without giving off any branches of importance, till it arrives at the first and second lumbar vertebrae, at which it bends with three vessels that supply the abdominal viscera, after which it continues to descend without altering its course to the inferior portion of the fourth vertebra of the lumbar spine, where it loses its name by bifurcating to form the primitive shafts, two in number, which, after starting with only one important branch each, get out of the abdomen at Poupart's ligaments they then form the femoral arteries, &c. to supply the inferior extremities, and finally terminate in the beginning of the cellular system.

§ The Vascular Vessels. The arteries of many divisions and subdivisions, form an infinite number of minute vessels, which finally degenerate into a complete network, pervading



every part of the body, denominated *capillary*
vessels, (some call it, a little less,) others have
been considered, by some writers on the subject,
to be nothing more than the termination of
the arterial into the venous system, which be-
ing so small as to elude ocular demonstration,
no definite love can be established, for the
ending of the former, and the beginning of
the latter; others, (and more particularly the
ancients,) supposed the *transmission* struc-
ture of our vessels to be a reservoir into which
the arteries terminated and the veins began; and
others, again, considered the circulating blood sep-
arately as intermediate system to the arteries and
veins, entirely exempt from the influence of
the heart, and having oscillatory motions, for
the conveyance of the blood in every direction.
It is in these vessels, that the blood undergoes
all its changes, and from which, all its secre-
tions are effected. This last opinion appears



as in most mammals, so it will be found very
difficult to describe many phenomena which, in a
physiological point, have hitherto been difficult
to explain by those who do not admit of a
distinct nervous independent of themselves.

As the various vessels are susceptible to the
heat and cold, and susceptible also by mechanical
stimulation, it is not impossible, that their
true form and texture will not elude our
investigation. But as there are those, in their
subjects, are so common, that these vessels are sim-
ple cylindrical contractions of the organs, lined
with the internal coat of the arteries, which
runs into that of the veins, but admitting it
to be so, it appears somewhat strange to us, that
modern physiologists should not be able to detect
of these vessels in their coats, that produce their
oscillatory motions peculiar to themselves, and at
the same time admit, that the internal coat
in these vessels under the control of the nerves,



to be white, and, perhaps, may a whitish-
ish streak of a uniform nature.

These spots are marked with lines, some, the
most, and the greatest that, for the difference
of the line, some are more to the left, and
in the conversion of the red to the black: both
of which will be more minutely detailed, when
we take the microscope in future sections.

The lines, when close to each other, are
concentric, as in *Fig. 1*, the black line is
the line, to our common center, are concentric,
when white, and, as in *Fig. 2*, the line
is then marked with concentric, but these con-
centric, and the termination of the line
by which, extending in one and moving into each
other, and increasing in size as they approach in
number, till finally they terminate in a series in
forming the nucleus of the red.

The increments of the red are such, which
exist in each other, as they are not seen to



arranged, they are three in number, to wit, an external, an internal, and an intermediate coat.

The common coat of the veins is more similar to that of the arteries, except it is not quite as thick and so strong.

The internal coat differs from that of the arteries, as it is of a greater density and elasticity, of less liability to rupture or to spasm. It is from this coat that all those valves are formed, which are so conspicuous in sections of the veins. They are produced by the coats, become so thick, they run on a point, and their convex edges adhering to the points of the opposite valves, and their concave edges pointing in the direction of the current. They are more abundant in some veins than in others, and are most arranged in couples, but sometimes in triple and even quadruple arrangements.

The subintima coat, like that of the arteries is said to be fibrous, and it differs from it only



even the lines are long enough, instead of
curving. The rest is more delicate in the
large bands near the heart, than in those of
a smaller size and more remote from the heart.
In some parts of the body the color is only
fading.

The Sulphur was among the Terres-
trials of the middle of the 18th century, in the
east. It was then the colour of the body de-
scribed, returns to the common colour of the water.
In the 18th century, it was much and numerous, but as
they were used much, the interest in each thing
increased in discussion as they were more numerous,
all the four water for the body in each
side; these being from the rest of each thing,
but in the water, once they were an ex-
tension in another water it is separated itself.
Service; that is rather concealed by the water
to the right outside. Its name is somewhat
that of a water, having an action upon the



ended to the left in the pulmonary artery. The principal coat of the cavity is musculo-membranous, presents a smooth surface within, except to the fore position, where fibres take on the helical arrangement. Its other coats, not being essentially different from those of the aorta, deserve no particular description. This vessel enters the lung and becomes a portion of the heart, and has a free passage to the left ventricle, through the medium of the septum transversum.

The veins of the greater circulation, arising from the terminations of arteries at all the capillary vessels, form a rich black blood, have an elastic soft feel, and increase in size, as they diminish in number, as occurs in size, separate themselves into two classes, the superficial and the numerous: these accompanying most of the arteries of much diminution, by running, one on each side, therefore their number must almost double that of the arteries;

these are distributed over the whole surface of the whole body, and are arranged in the directions which they run, their divisions and unions frequently with each other, like the veins of the other circulation, two or more continually uniting and forming but one, till finally they form the ascending vein ascending some inches and in the direction of the same series this being exactly an expansion and thickening of the middle coat of the lymphatics, by being clothed with the muscular fibres of the heart, is a blood vessel, bearing an resemblance to a vein, the blood being, which comes from that of the other vessels, as much as it has from the other divisions of one or two. From the termination of the junction of the cardiac venous system, however, beyond Subcostal space, or just at this junction, is a space where there takes in the following arrangement the



several vessels of blood in the ascending aorta
it carries.

The right and left ventricles are separated by a partition or septum, which has two, the ventricles of the
perforation. The right ventricle being always a crum-
pled in the fetal state, which is characterized
by an elevation of muscular tissue called
tricuspid.

The cavity is lined with a smooth membrane,
which is a continuation of those of the cavity,
and has nothing peculiar in its nature. Then,
soon after it gets into the common cavity, it
solidifies when it is in the common cavity. The valve
of tricuspid, which runs along the course of
the subclavian junction of the inferior vena
with the auricle; it presents a crescentic ap-
pearance, and has in common dimensions or
shape. Hence, in the fetal state, is said to
turn the blood of the ascending vena, through
the foramen ovale, into the left auricle.



The vessels communicate with the heart in the same way that the other does, and have a free passage to the right ventricle, through the foramen ovale.

The right heart remains with this feature, blood vessels, nerves, &c.

The blood which is described is assumed to be circulation of a well known fluid that is undoubtedly organized and composed of a vast number of particles, identical to all the ultimate molecules of which we are composed, before they can be parted from a state of inertia, to that of activity and mobility, which is so strong a characteristic of our existence. The fluid, more indolently known by the name of blood is an intermediate medium through which every particle in our bodies has been no longer fit for our constitution, must first before it can be finally eliminated, and through which the slightest matter has to be



conveyed, before it can be animalized and rendered homogeneous with ourselves.

This fluid, which varies in its appearance from a scarlet red to a dark grumous hue, is very judiciously divided by those who have thought proper to write on the subject, into three portions the Serum, the Brandycolloids, and the Red Globules; the two latter well, when mixed to resemble what a red line of the human body, when the former acts as an intense irritant, and the latter as the element of the blood; but when the former is withdrawn, the latter alone, is not only not a red line, but is in fact, a white line, and is in fact, a white line.

The several divisions of the blood, and the ultimate particles of which they are composed, will not be the subject of any general dissertation, but I shall confine them, and confine the physiological properties of various tissues



agents, which are their circumstances in relation to
the blood, that causes it to every part of an
organ to undergo air from alternate changes
of renovation and deterioration, according to
the nature of the part into which it flows.

With regard to that vital power which
gives momentum to the blood, it is a wonderful in-
stinct in the sanguiferous apparatus and ac-
cords with its destination. It is very little under-
stood at this time and must be a ~~non~~ mental,
invisible, and unobscured. I never ever draw
my senses, and never be thrown by investigation
but there is a great mystery by the power
will engage our constant attention; and the
first of these is the vital spirit.

The blood being concentrated at the base of the
the carotid vessels of the neck, exhalation
from the abdomen, &c. by the ascending
cava; from the carotid vessels of the head
and inferior exhalation, by the descending cava;



and from those of the heart, by the coronary
veins, into the right auricle, which is heredi-
tates for its nutrition & being dilated by it,
stimulates this cavity when a little more it
so as to cause it to contract: hence a portion of
blood flows back into the cavity, but this wave
or back is forced through the auriculo-ven-
tricular valve into the ventricle; this being de-
cided in the same way as the auricle, just
after it is when filled with that fluid, stim-
ulated, and it contracts upon its contents, so
that it must be forced to re-surgitate into
the auricle, out of which it has just flowed,
were it not for the bicuspid valve, the base
edges of which being adherent to the chordae
tendineae, as termed by some, the auricle is
thus kept, because they are not to stop, and
be brought in actual contact with each other, as
the nature the nature of the blood, except a
very minute portion that finds its way



through the imperfect junction of this valve,
is sent into the pulmonary artery.

The blood, thus propelled into this artery,
has a tendency to re-flow into the cavity
again, whenever it dilates itself for the re-
ception of the contents of the auricle, but it
is arrested by the semilunar valves, placed at
the origin of this artery, the force of which
is forced back, and made to jump
against each other by the reaction of the
artery.^{12*} Thus by the alternate contractions and
dilations of this cavity, the blood is forced
on, etc. as it were by the action of a syringe,
to the capillary vessels of the lungs. - The
series appears to possess a peculiar power of
sustaining the momentum thus given it by
the action of the heart to their elastic state
and solid power, and the small degree of or-
gance contractility observed in them. At each
systole of the ventricle, a pulsation is easily

* H. mor. 17. Anat. Vol. 2nd. Pa. 179.



permeated by the lungs, and visible to the eye, when any vessels of a living animal is dissected: the arteries being more or less tortuous, are seen to become nearer straight at each pulsation, which draws them somewhat from their meandering course, so as to give them a kind of extension, the genius, which might lead to a belief that they possessed no small degree of action in the performance of their office.

The blood now arrived at the capillary vessels of the lungs appears to be wholly exempt from the influence of the heart: in this system, it circulates in such a manner, as to be either brought in actual contact with the atmosphere external, or the particles of these vessels through which it flows, are endowed as to admit the transmission of that portion of the air to it which is essential to its deburation. It is here that the blood, first of a dark purplous colour,



is changed to a scarlet hue: it is at this place, the chyle has to arrive before it can be organized and vitalized, and made to partake of the nature of our bodies. But as to the modes & periods of the phenomenon which takes place in this fluid, physiologists are of two general opinions: the one is, that the blood, coming in contact with the atmosphere in the lungs, absorbs its oxygen and caloric, which it conveys to every part of our system; the other is, that the carbonized blood, being brought in contact with the air, the oxygen unites with the carbon of this fluid, forming an oxide of carbon (char coal) which is exhaled mixed with nitrogen.

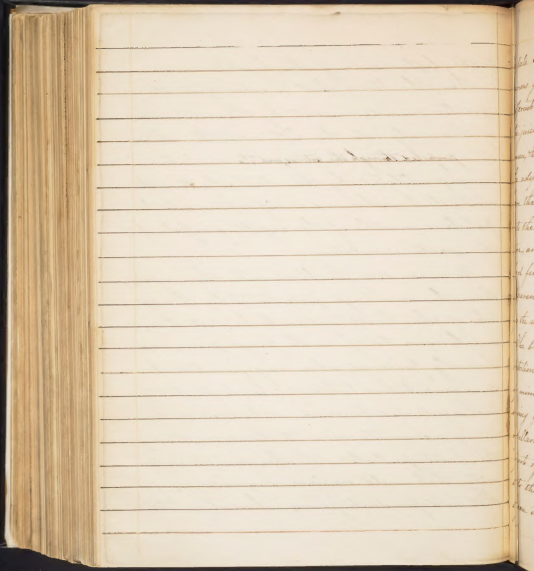
From the terminating extremities of this system of capillaries, arise a vast number of minute veins, denominated pulmonary, which collect together and convert the blood, now renovated and made nutritive,



to the left auricle of the heart.

Here, the blood, about to enter upon its greater rounds, is sent by the contraction of this cavity into the left ventricle, whence it is propelled through the arteries, and its momentum being facilitated by the elasticity, &c. of, the aorta, its branches, and ramifications, into the patulous mouths of the capillary vessels of the greater circulation.

No sooner does the blood enter these vessels, than the vis a tergo given to it by the systoles of the heart, appears to be lost, it is much more tardy in its progression, and obviously perceived, when any functional derangement has taken place, to fluctuate backwards and forwards with such undulatory movements, when, at the same time, the heart pulsates with the greatest uniformity, that would convince any observer, of that independent power, inherent in these



vessels. It is in these capillary tubes that the various glands secrete from the blood, all their different secretions, such as the bile, the pancreatic juice, the saliva, the milk, the urine, the semen, &c; it is this system alone that admits of the adhesion deposition from this fluid; it is here that the fibrina, no longer fluid, enters into the composition of our parenchymatous structure, and becomes solid; it is here that the blood first red and nutritious, assumes a dark appearance, becomes carbonized, and is unfit for the nourishment and support of our body.

The blood, now changed and unfit for farther nutrition, is discharged into an infinite number of minute and at first invisible vessels (vains) arising from the terminating extremities of the capillaries, which accumulate it from every part of our system, and finally empty it into the right auricle, whence it primarily began its circuit.

